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December 17, 2008

U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: Document Control Desk

Subject: Duke Energy Carolinas, LLC (Duke)
McGuire Nuclear Station, Units 1 and 2
Docket Nos. 50-369 and 50-370

Response to Request for Additional Information related to the License Amendment Request for Implementation of Alternative Source Term.

Reference 1: Duke letter to NRC dated May 28, 2008
Reference 2: Duke letter to NRC dated March 20, 2008
Reference 3: Duke letter to NRC dated October 6, 2008

This letter provides the responses to the most recent request for additional information (RAI) conveyed by the NRC staff via electronic mail from John F. Stang on October 3, 2008. The NRC staff's questions and Duke's responses are provided in Attachment 1.

Following a teleconference with the NRC staff on October 20, 2008, problems were identified with the meteorological data used to calculate atmospheric dispersion factors. These problems were entered into the McGuire corrective action program for cause determination. Additional details are contained in Attachment 1.

The conclusions reached in the original determination that the LAR contains No Significant Hazards Considerations and the basis for the categorical exclusion

C001
A001
NRR

from performing an Environmental/Impact Statement have not changed as a result of this request for additional information.

Please contact Lee A. Hentz at 704-875-4187 if additional questions arise regarding this license amendment request.

Sincerely,

Bruce Hamilton

Bruce H. Hamilton

Attachment

cc: w/attachment

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OATH AND AFFIRMATION

Bruce H. Hamilton affirms that he is the person who subscribed his name to the foregoing statement, and that all the matters and facts set forth herein are true and correct to the best of his knowledge.

Bruce Hamilton

Bruce H. Hamilton, Site Vice President

Subscribed and sworn to me: December 17, 2008

Date

Tori C. Dibby

Notary Public

My commission expires: July 1, 2012

Date

ATTACHMENT 1

Duke Response to Meteorological Data Quality Issues

During the review of the McGuire Alternative Source Term License Amendment Request, NRC Staff identified multiple errors related to the inputs used to compute the dispersion factors. In the process of responding to the most recent set of questions from the Staff (responses follow below), additional errors were identified. The errors have been entered into the Duke Problem Investigation Process (corrective action program) as PIP numbers M-08-2835, M-08-6746, and M-08-7314. While the specific error identified in each instance was different, they all occurred in the same analysis and they demonstrate a breakdown in the performance of the Engineering calculation process. The cause evaluations of these errors identified weaknesses in the detailed independent review of this work and in the application of the principles of self-checking during the analysis.

This performance does not meet Duke's standards for analysis quality. In view of this history, Duke retained an outside vendor to independently review this analysis and its results. This effort was undertaken to increase the confidence in the quality of these results and the confidence in future submittals of data based upon this analysis. Duke management made the completion of this review and the resolution of any ensuing issues a prerequisite for responding to these RAIs. The control room atmospheric dispersion factors have been updated to reflect the resolution of internally and externally identified issues.

The recent errors were related to the processing of the measured wind speed input to the ARCON96 code and to hand calculations using the Murphy-Campe methodology to compute dispersion factors for two sources where the distance to the receptor was less than 10 meters. Resolution of these errors impacts all of the previously submitted dispersion factors. All dispersion factors are superseded by those attached in Appendix D of these responses. Some dispersion values did not change because the impact of the dispersion model modifications was not large enough to affect the result to the number of significant digits used in the results.

All identified errors have been corrected and the dispersion factors used in the LOCA analysis have changed. These RAI responses reflect the most recent dispersion factor analysis. The changes to the dispersion factors are responsible for the revised doses. Updated tables and text are provided in Appendix D for those parts of the license amendment package impacted.

These issues directly affect only the control room dispersion factor calculations. System response models (including the control room ventilation system model) are not impacted by these changes because the errors were only in the meteorological work. The LOCA effluent dose calculations have been updated to reflect the impact of the resolution of these dispersion modeling issues.

The updated analyses are used to support the RAI responses which follow.

Additional Information (Meteorology) for the Office of Nuclear Reactor Regulation, Division of Risk Assessment, Accident Dose Branch regarding the Implementation of Alternative Source Term License Amendment Request submitted by McGuire.

Question 1

Regarding the ARCON96 formatted files provided as Appendix D of Attachment 1 to the May 28, 2008 supplement (Agencywide Documents Access and Management System (ADAMS) Accession No. ML081560395), it appears to the NRC staff that there are unusually frequent and seemingly random increases and decreases in wind speed: 1) within individual hours between the two measurement heights and 2) between hours for data at a single height. Therefore, please confirm that the raw hourly wind speed measurements have been correctly processed and formatted for input to the ARCON96 computer code and provide a detailed discussion of wind speed variability at the McGuire site.

Response

Sporadic wind speed shifts in the ARCON96 meteorological (MET) files were discussed with NRC Staff in a teleconference on October 20, 2008. All of the wind speed data used in the ARCON96 analysis has been evaluated and it has been determined that these shifts were caused by a formatting problem associated with the wind speed entries in the ARCON96 meteorological data files (McGuire PIP M-08-6746). This formatting issue is related to the wind speed parameter and is different from the input file formatting issue identified in Reference 1 (McGuire PIP M-08-2835).

Background

The ARCON96 computer code is used to compute the atmospheric dispersion factors for McGuire Nuclear Station (MNS). Wind speed data is supplied to the ARCON96 code through the meteorological input files (MET files). However, the wind speed data supplied to the code must be in integer format (without decimal points). This requires that the meteorological data supplied by the meteorological tower (which is measured to a resolution of a tenth of a mile per hour— mph) be converted to the format expected by the code. Thus, when the user reformats the entry to remove the decimal point, this action has the same effect as multiplying the measured wind speed data by 10. In processing the MET files, ARCON96 internally adjusts the supplied wind speeds which should produce the originally measured wind speeds (to a resolution of one-tenth of a mph).

Wind Speed Variability at Each Individual Height and Wind Speed Format Error

The archived meteorological data (from 2001-2005) was converted into the ARCON96 MET data files by importing it into a spreadsheet where it was manually processed and formatted. A comparison of the spreadsheets used and the resulting MET input files (for example, Julian Day 2 in year 2001), showed that the recorded wind speed data with a decimal digit of "0" was processed incorrectly when importing/parsing the ASCII text file in the spreadsheet. The original meteorological data downloaded from the archived QA McGuire dataset possesses wind speed measurements to one-tenth of a mph for all hours of data. A test of data importing/parsing in the Microsoft EXCEL spreadsheet software confirmed that when a number with a decimal digit of zero is imported, the zero behind the decimal is truncated. Thus, for example, a measured value of "15.0" would have been processed by the spreadsheet parsing truncation to be "15" in the ARCON96 MET data input file. With no decimal point to remove, these values did not get the inherent factor of 10 applied by that action so this value remained as "15". The ARCON96 code would have internally converted this wind speed input to a value of "1.5," as ARCON96 reinserts the decimal point.

This error affects both the 10m and the 60m wind speed inputs to ARCON96 in the 2001-2005 modeling. This data has been corrected and re-modeled in the current analysis. With lower wind speeds modeled, ARCON96 can implement a "low wind meander" of the plume which spreads it across a greater area and results in the production of lower X/Qs. Thus, most of the maximum X/Q values have increased as a result of the corrections to the ARCON96 MET file wind speed format. Revised dispersion results are included in Appendix D (Table B-3) of this response.

Wind Speed Variability Between Measurement Heights

Prior to the May 2008 supplement (Reference 1) to the AST LAR submittal, the 2001-2005 QA meteorological data for McGuire was verified per NRC Staff recommendation. The meteorological files formatted for input into the current ARCON96 analysis have since been compared against the QA archived data to confirm no additional formatting issues exist. Both internal and external reviews of the meteorological data and the dispersion factor calculations and modeling were performed. Prior to those reviews, the specific data questioned in the October 20, 2008 teleconference were reviewed and the identified issues resolved.

For all years (2001-2005), hours in which the 10m wind speed exceeded the 60m wind speed were examined. These hours usually occurred under neutral conditions, although some instances were observed for all stability classes. Around a lake (McGuire is sited on Lake Norman), microscale air flows are induced by differences in surface roughness and albedo. During light wind conditions with good daytime heating, these microscale flows influence the conditions around the lakeshore more than synoptic conditions, and in these cases, the wind speed differences appear to occur during the transition from stable to neutral stability conditions.

- Only one hour of this data was found to be in error (hour 9 on September 9, 2002). The human error occurred during the manual editing process prior to the archiving stage. This error is separate from the formatting error described above. This hour of data was corrected for wind speeds, directions, and stability class.
- For most of the hours where the 10m wind speed was greater than the 60m wind speed, the differences were around 1 mph or less. These readings were judged to be valid, due to the acceptable calibration error range for the wind speed loop accuracy (± 0.5 mph) with a resolution of one-tenth a mph. These errors alone could produce measured differences of ± 1 mph in the presence of identical wind speeds at both measurement levels.
- In the remaining cases reviewed, the 10m wind speed exceeded the 60m wind speed by 2 - 5 mph. These cases were mainly related to precipitation events including, but not limited to, days with freezing rain or wintry mix in the Charlotte area. However, because most of these events occurred with wind speeds greater than 3 mph, frozen anemometer cups at the 60m level is not a likely cause of these differences. In fact, some of the lighter wind speed hours (less than 3 mph) occurred on sunny days. These hours were also accepted as valid readings.

Hours in which the 60m wind speed exceeded the 10m wind speed by 10 mph or more were evaluated and accepted as valid. Most of these instances occurred at night, or during early morning with stable atmospheric conditions (stability classes F and G), based on vertical temperature gradient measurements. The lighter wind speeds at the 10m level support the flow separation of the surface layer from the 60m level of measurements on the tower. This also indicates a potential for cool air drainage flow down into the river valley under stable conditions when an internal boundary layer can form within the surface layer. The exception was a daytime occurrence of 60m winds much greater than the 10m winds on March 20, 2001 (hours 15 and 17), with neutral conditions associated with a rain/sleet event and higher winds (18-33 mph).

<u>Wind Speed Variability at McGuire Site</u>

Variability in wind speed measurements (i.e. acceleration) at a single level, or between upper and lower levels on the meteorological tower, can be related to the location of the McGuire plant at the south end of Lake Norman. The presence of the lake reduces the surface roughness in the WNW, NW, N, and NE directions near the meteorological tower, and thus minimizes boundary layer friction that would otherwise serve to equalize surface layer wind speeds across an open expanse of land. The Catawba River flows in a southerly direction downstream from Lake Norman, in a fairly deep river channel below the dam at the McGuire site. The terrain on site drops off in man-made plateaus, stepping down toward the river on the SW and West side of the plant, below the dam. For the local vicinity away from the river, however, the terrain is gently rolling and typical of the Piedmont region of the Carolinas. Land use is rural, and historically residential, with tracts of farm land and wooded areas. However, local development is now increasing beyond residential, with significantly more restaurants, small businesses and retail stores being built in the vicinity within the last 5 years.

The meteorological tower is located roughly to the NNE, along the shoreline between the McGuire plant and the lake. It meets the 10L criteria for distance from obstructions. However, locally induced circulations are possible. Local flow can be influenced by the exchange of thermal energy between the air and sea interface, which strives to balance the energy budget between the land and water surfaces (e.g. spatial differences in temperature due to solar heating and intrinsic heat capacity of the surfaces). Also, with the abrupt change in surface roughness near the shoreline of the lake, wind flow may be accelerated or decelerated quickly, leading to gustier winds at the surface (i.e. wind speed shear and wind direction shear).

Conclusions

An error in the ARCON96 MET data wind speed formatting was introduced during the preparation of these input files. Revised MET files have been produced and the dispersion factors recomputed. These changes impact the previously submitted data and results. An external, independent review of the revised ARCON96 meteorological input files and dispersion factors has been performed. Updated MET files and dispersion factor tables are provided in Appendix D (Table B-3) to this response and are discussed in more detail below. This problem was entered into the McGuire corrective action program as PIP M-08-6746 for cause determination.

The updated information includes changes to the dispersion factors and the subsequently recomputed effluent control room LOCA doses. Neither the conclusions of the LOCA analysis nor the conclusions of the No Significant Hazards evaluation is changed or modified as a result of these updates to the License Amendment Request submitted in Reference 2 and amended in References 1 and 3.

Updates to the AST LOCA License Amendment Submittals

Due to the wind speed formatting issue discussed above and resolved in response to this Request for Additional Information (RAI), changes were made to the ARCON96 meteorological files. The ARCON96 dispersion factors were recomputed using the updated meteorological input files, resulting in changes to the dispersion factors. These changes affect Tables 15 through 18, Table 5-1, Table B-2, Table B-3, and Section 4.10 of the LAR. These tables and text are updated and replaced by those provided in Appendix D of this RAI response.

The purpose of each of these tables was discussed in the original LAR and in some of the responses in this correspondence. In summary:

- Table B-2 provides the input parameters for the ARCON96 modeling. Four corrections were made: changed the sigma-Y values for NDOG, VNDOG, and RX, and changed the sigma-Z value for FUEL. Although the corrections are on the first of the three pages of this table, the entire table is included in Appendix D for completeness.
- Table B-3 provides the entire suite of updated dispersion factors associated with all of the potential release locations which might be postulated for any of the design basis accident analyses. All of the values in this table are updated as a result of the discussions in response to Question 1 (above) and Question 3 (below). Additionally, those dispersion factors used in the LOCA analysis are shaded in the new Table B-3, as requested. Note that the shaded cells are also the values provided in Table 16.
- In order to provide a more focused discussion in the LAR, the dispersion factors associated with the modeled LOCA release locations were summarized in Table 15. The response to Question 2 (below) cites the discussion in the original LAR of the possibility of a release from the Purge System (VP) intakes during a LOCA and the determination that releases from this location would be bounded by the dispersion factors from the unit vent (UV). In order to more easily compare these values and demonstrate this conclusion, the VP dispersion factors are added to the updated Table 15 attached in Appendix D of this response.
- Table 16 is a refinement of Table 15. Table 16 shows only the dispersion factors associated with release locations modeled in the LOCA analysis. Overlapping time periods in Table 15 are removed to show factors for consecutive time periods for the duration of the analysis. The dispersion factors shown in Table 16 have not been modified to reflect the impact of McGuire's status as a "dual intake" plant.
- Table 17 is a modification of Table 16. It reflects the "dual intake" status. Table 17 reflects the 65/35 bounding flow split assumed for the Control Room Ventilation System (based upon plant testing, Reference 3). The values in Table 17 were produced by multiplying the values in Table 16 by 65%.
- Because the dispersion factors are an input to the control room dose computations, the changes in the dispersion factors impact the computed control room doses. The control room doses were recomputed with the new dispersion factors. No other changes were made to the effluent release model. An updated Table 18, an updated Section 4.10, and an updated Table 5-1 are provided in Appendix D to reflect the resulting control room dose. The conclusions previously communicated with regard to the acceptance of the doses and the No Significant Hazards evaluation are not impacted by the change in the control room doses.

- A CD with the new ARCON96 MET files is also attached in Appendix D to these responses. The files on this CD replace the previously supplied data files (on CD). There is one MET file for each of the five years of data with filename structure of "MyyyyR6.met" (where yyyy indicates the calendar year associated with the data) to distinguish them from previously supplied versions.

Question 2

Table 17 of Attachment 1 to the May 28, 2008 letter lists atmospheric dispersion factors (χ/Q values) for three release locations, the unit vent, equipment hatch, and refueling water storage tank, which were identified as limiting in the March 20, 2008 license amendment request (LAR) (ADAMS Accession No. ML080930505). Table B-3 of Attachment 1 provides χ/Q values for seventeen locations, including the previously mentioned three locations. Are all of the χ/Q values in Table B-3 applicable for consideration in this LAR? NRC staff notes that χ/Q values for some of the other seventeen locations, as listed in Table B-3, are higher than those for the three locations identified in Table 17. Which locations in Table B-3 were compared to determine that each of the three locations in Table 17 were limiting?

Response

Table B-3 provides dispersion factors for potential activity release points which could be postulated at McGuire Nuclear Station for design basis accidents. The LOCA response model uses a subset of these release points. The others are not germane to a LOCA. The postulated LOCA activity release points are identified in Table 17. These release points were determined through a review of the integrated plant response which also considered other possible release locations (see discussion in Sections 4.3 and 4.5 of the LAR, Reference 2).

In response to conditions imposed in the McGuire AST Fuel Handling Accident amendment Safety Evaluation Report (Reference 4), the entire population of dispersion factors associated with potential release locations (for any potential accident) were recomputed and submitted with the full scope AST (LOCA) LAR [see Reference 2 page 51 (bottom), page 52 (middle), and Appendix B (beginning)]. In the response to Question 3 of the previous Request for Additional Information (Reference 3), Duke stated its intention to incorporate AST into the remaining design basis analyses on an as needed basis following approval of full scope implementation. The submittal of the full population of dispersion factors associated with potential release locations (Table B-3) which could impact any of the design basis accidents was made to satisfy the condition imposed on the control room dispersion factors in Reference 4 (reprinted in Appendix B of Reference 2). A review of the re-computed dispersion factors will support future implementation of AST for the remaining design basis accidents at McGuire.

LAR Sections 4.3 and 4.5 (Reference 2) discuss post-LOCA activity transport and identify potential credible release locations based upon the plant's response. LAR Section 4.7.2 (Reference 2) summarizes the credible release points. However, potential leakage from other release points was also considered. Leakage from the Purge System (VP) intakes was postulated (see second half of Section 4.5.1 of Reference 2), but the dispersion factors associated with it were found to be bounded by the unit vent dispersion factors, so potential leakage from VP intakes was conservatively assumed to be released from the unit vent.

Many release locations, including those with higher dispersion values (as shown in Table B-3) were considered but eliminated from the model as insignificant or non-credible in an evaluation of the radiological impacts of a LOCA. However, these release locations may be significant or credible for other design basis accidents, so their dispersion factors could be needed for future AST implementation analyses.

Therefore, in order to address the concerns raised in the AST FHA SER (Reference 4), a suite of control room dispersion factors was included in the data submitted in Appendix B of the full scope AST LOCA LAR (and are updated in Appendix D of this response package). These release locations were not just limited to the LOCA scenario; they could be applicable to other design basis scenarios analyzed in the future as AST is implemented.

<u>**Question 3**</u>

NRC staff notes that the χ/Q value of 1.26×10^{-3} sec/m^3 listed in Table B-3 seems quite low for a source/receptor distance of either 2 or 9 meters as listed in Table B-2 of Attachment 1 to the March 20, 2008 LAR. Please provide a list of the inputs and assumptions and discuss how the Murphy-Campe methodology was implemented to obtain this value.

<u>Response</u>

The Murphy-Campe method (Reference 5, equation 6) was used when the distance between the source and receptor was less than 10m because the ARCON96 model is not valid at such close proximity. This is comparable to equation 8 in RG 1.194 (Reference 6), however, this equation was applied assuming a plant with dual intakes (i.e. "Point or Diffuse Source with Two Alternate Receptors" and "Dual Inlets Located on Seismic Category I

Structures"). Thus, the K value was set to zero, in accordance with both Reference 5 section V.B.1.c(1) and Reference 6 Regulatory Position 4.3.

The Murphy-Campe methodology was used for the reactor building surface (RX), and for the main steam safety valves on the Outboard Doghouse (MSSVo) when the receptor intake is on the same unit as the source. Note that if the source and receptor were on opposite units, then the ARCON96 model was used (e.g. for much larger distances). Neither of these source locations was determined to be significant or credible activity release locations for the LOCA analysis.

- Sources were treated as ground-level releases in the Murphy-Campe calculation and in the ARCON96 modeling. For example, in the Murphy-Campe calculation the following source characteristics were used:
    - RX — containment building surface treated as a vertical area source at 2.1 m distance and release height of 0 m.
    - MSSVo — main steam safety valves on the Outboard Doghouse treated as a point source at the closest distance of 9 m, and release height of 18.8 m.
- Although the effluent from the main steam safety valves (MSSVo) has a high vertical velocity and thermally buoyant plume, no credit was taken in the calculations or modeling (i.e. plume height was not adjusted).
- In the Murphy-Campe X/Q calculation, the wind direction factors and the control room occupancy factors were not applied to the release from the reactor building (RX) surface or main steam safety valves (MSSVo). Occupancy factors are applied in the dose calculations.

After the receipt of this question, an omission of a parenthesis in the Murphy-Campe calculation was identified (PIP M-08-7314), resulting in the computation of dispersion factors which did not properly reflect the impact of the changing wind speed inputs. The values for MSSVo and RX have been recomputed using conservative wind speeds for the 0-2 hour and 0-4 hour time periods. The recomputed dispersion factors are reflected in the new Table B-3 in Appendix D of this response.

Previously, the computed dispersion factors were constant with time as opposed to decreasing with time. The set of recomputed RX and MSSVo values exhibits time dependent behavior similar to ARCON96 computed values, with one exception: the value for the 8-24 hr period is slightly greater than for the 4-8 hr period.

The conservative value for the 8-24 hour period results from the conservative methodology used to determine the wind speed from the cumulative frequency distribution. For this time period, Table 1 of Reference 6 requires the use of the 10^{th} percentile wind speed. The two McGuire cumulative frequency wind speeds associated with this requirement are 1.35 m/s (10.09 percentile) and 1.305 m/s

(9.27 percentile). While the former would be closer to an interpolated 10th percentile value, Duke's methodology for these computations has been to take the wind speed associated with the required percentile (if available) or the next more restrictive computed percentile. Thus, a wind speed of 1.305 m/s was applied for the Murphy-Campe computations for this time period, recognizing that it is being applied conservatively.

Appendix A to these responses describes the Murphy-Campe methodology and how it was applied for these two sources (RX, MSSVo) when distances to the intake receptors were less than 10m. Note that the method of calculating values for sigma-Y and sigma-Z (originally taken from the SSIGMA subroutine in Appendix F of NUREG/CR-5055, Reference 7) is the same as the method used by ARCON96 (i.e. NSIGMA1 subroutine in Appendix A.7 of NUREG/CR-6331, Reference 8). Also note that the wind speeds used for time periods shorter than those in Table 1 of Reference 6 were extrapolated to tighter criteria than the 0-8 hour fifth percentile wind speed requirement. The 0-4 hour wind speed was selected as half of the percentile used for the 0-8 hour period. The 0-2 hour wind speed was selected as half of the 0-4 hour period. Thus, the 0-4 hour wind speed used was subject to a 2.5 percentile requirement, and the 0-2 hour wind speed used was subject to a 1.25 percentile requirement. This data is tabulated in Table A-3 in Appendix A of this response.

Question 4

Page 56 of Attachment 1 to the March 20, 2008 LAR states that the χ/Q values in Table 17 were used as input to the unfiltered inleakage dose assessment. However, these χ/Q values represent 65 percent of the magnitude of the χ/Q values outside of the control room air intake due to the 65/35 flow split credit for dual intakes. Please provide detailed justification that use of these reduced χ/Q values is appropriate assuming unfiltered inleakage.

Response

Section 4.7.3 of the LAR concluded that the most likely and most bounding path for control room in-leakage is via the Control Room Ventilation System, including its inlets. This provides the shortest and easiest flow path for unfiltered radioactivity to enter the control room. LAR Section 4.6.9 (Reference 2) discusses the control room ventilation system model and the classification of McGuire as a "dual intake" plant. The Control Room Ventilation System is assumed to be aligned such that two inlets are open at one intake location and one inlet is open at the other intake location. One inlet at one intake location was conservatively assumed to be closed. The two intake headers are cross connected prior to the suction to the outside air pressurization filter train fans.

This provides an air flow path to the control room from both intake locations and from both train headers.

LAR Section 4.7.2 (Reference 2) and the response to Question 5 of the previous Request for Additional Information (Reference 3), discuss the basis of the flow split assumed and the nine different Control Room Ventilation System configurations used in the plant testing performed to support the flow split value modeled. Reference 3 also includes further detail on the construction of the Control Room Ventilation System and a system drawing. Because the postulated leakage flow path is associated with the Control Room Ventilation System, the dispersion factors applied to unfiltered in-leakage should reflect the alignment of the system while the leakage occurs. Therefore, the flow split model bounds the postulated alignments of the Control Room Ventilation System and the condition of the system when the in-leakage is postulated to occur.

Question 5

Is the Appendix A drawing of the March 20, 2008 LAR drawn to scale? If so, please provide the scale used for the drawing. Are all of the postulated release locations applicable to this LAR clearly highlighted to enable NRC staff to make confirmatory estimates of the selected inputs and assumptions? If not, please highlight all postulated release locations on a revised scale drawing and provide to NRC staff.

Response

Yes, the plant sketch that was included in Appendix A to the original LAR submittal (Reference 2) was drawn to scale (originally 1"=100 ft), but it is not an "engineering drawing." Also, the figure supplied with the original LAR submittal (Reference 2) was not scanned to full original size so application of the scale to that sketch would not have been appropriate. Thus, both the original sketch and the marked-up version attached in Appendix B of this response should be treated as approximate, since they (a) are largely based on McGuire Nuclear Station "fly-over" data (Microstation format) with uncertainties inherent to aerial surveys, (b) have been reproduced by scanning and via copy machines, and (c) the updated sketch includes source locations plotted by hand. To verify the scale, note that the diameter of each reactor building (Unit 1 and Unit 2) is 130 feet.

Straight-line distances and directions used in the calculation were determined from station drawings and cross-checked with photos made during a station walk-down in the year 2000. They were also checked during the creation of the original Microstation figure from the fly-over's digitized data. Arc-length distances were measured using Microstation software tools.

Exact locations of all of the sources were not shown on the figure in Appendix A of the original LAR (Reference 2). A marked-up version of that sketch is included as Appendix B of this response. It should be used by applying the scaling to estimate distances. The locations of the all sources have been clarified on the sketch in Appendix B of this response package, as described below:

- EQ – (EQ1, EQ2): releases from the Unit 1 equipment hatch emit directly to ambient air; the Unit 2 equipment hatch is located inside the Equipment Staging Building and therefore would emit to ambient air through the roll-up door on the east side of the building.
- FUEL – (F_a, F_b, F_c, F_d): F_a and F_d source locations were used with source-receptor on the same unit; locations F_b and F_c were used with source-receptor on opposite units.
- NDOG, VNDOG – (NDOG, VNDOG): assumes releases at the middle of the grating on the south end of the inboard/interior doghouses on Units 1 and 2, closest corner to the respective intakes.
- ODOG, VODOG – (ODOG, VODOG): assumes releases through the middle of the grating on the south side of the outboard/exterior doghouses on Units 1 and 2.
- RX – (Rx_a, Rx_b, Rx_c, Rx_d): postulated release through the containment/reactor building wall; closest distance taken between intake and containment; Rx_a and Rx_d are adjacent to the control room intakes; Rx_b and Rx_c are closest points to intakes on opposite units.
- FWST – (FWST): release from the top of the feedwater storage tank for each unit.
- UV – shown on the figure as "Unit 1 Vent" and "Unit 2 Vent."
- VP – (VP1; VP2): containment purge system supply intake for each unit.
- AGIN – (AGIN): steam & feedwater line penetrations on the inboard/interior doghouse wall on each unit. There are two steam lines and two feedwater lines entering the south side of the inboard doghouse wall; the steam lines are located at a higher elevation and farther away from containment. The steam line location closest to the middle of the doghouse wall was used.
- AGOUT – (AGOUT): steam & feedwater line penetrations on the outboard/exterior doghouse wall on each unit. There are two steam lines and two feedwater lines entering the south side of the outboard doghouse wall; the steam lines are located at a higher elevation and

farther away from containment. The steam line location closest to the middle of the doghouse wall was used.

- PORVin – (P): steam generator power operated relief valves on the inboard doghouse on Unit 1 and Unit 2. There are two valves on the inboard doghouse for each unit, denoted by P(x) for source-receptor on the same unit and P(.) for source-receptor on opposite units.

- PORVout – (P): steam generator power operated relief valves on the outboard doghouse on Unit 1 and Unit 2. There are two valves on the outboard doghouse for each unit. The valve denoted by P(x) was used for all model runs.

- MSSVin – (M): main steam safety valves on the inboard doghouse on Unit 1 and Unit 2. There are two rows of valves on the inboard doghouse for each unit. The valve on the south end of the row adjacent to the containment building was used.

- MSSVout – (M): main steam safety valves on the outboard doghouse on Unit 1 and Unit 2. There are two rows of valves on the outboard doghouse for each unit. The valve on the south end of the row adjacent to the containment building was used.

Question 6

What are the heights of the control room intakes? With regard to the input values listed in Appendix B, Table B-2 of Attachment 1 to the March 20, 2008 LAR, what is the basis for the initial sigma values and release heights, other than when specific vents are assumed? Were the distance inputs into the ARCON96 calculations directly estimated as horizontal straight line distances or was another methodology (e.g., a "taut string" methodology) used to estimate the distances? If the distances were not estimated directly as straight line horizontal distances, how were they determined? Did the procedure used to estimate the distances properly factor in differences in heights between each source and receptor?

Response

Control Room Air Intake and Release Heights

McGuire control room air intakes are located on the roof of the Auxiliary Building near the outboard/exterior doghouses. There are two intake locations, with two inlets at each. Each intake is located beside a Reactor Building. Together these two intake locations serve as dual intakes for either unit (i.e. alternate receptors).

The intakes are turned downward in a candy-cane shape, with the inlets located at a height of 4.9 ft (i.e. 1.5 m) above the roof elevation. The intake inlets are at an elevation of 771.9 ft mean sea level (msl), or a height of 11.9 ft (i.e. 3.6 m) above plant grade (760 ft msl). The Auxiliary Building roof elevation at the location of the air intakes is 767 ft msl. Thus, the base elevation difference of the intakes is 7 ft above plant grade (i.e. 2.1 m above plant grade).

The release height for each source was input to the model relative to plant grade. The McGuire intake height was taken relative to the inlet height above the Auxiliary Building roof where it is located. Since the base elevation of the receptor is greater than that of the source, the "elevation difference" between source and receptor was entered into ARCON96 as a negative value (i.e. -2.1m), following the guidance in NUREG/CR-6331 (Reference 8, section 2.3.4).

Basis for SIGMA Values

The method used for calculating initial sigma-Y and sigma-Z values as inputs to ARCON96 is taken from Regulatory Guide 1.194 (Reference 6), and is described in Appendix C of this response. For point sources, the sigma values are initially set to zero. For horizontal and vertical sources, the sigma values are based on the width and height of the area source, divided by 6.

Distance Between Source and Receptor

Distances input to ARCON96 for each source to receptor combination are horizontal distances, without consideration for any vertical separation. Distances are either straight-line horizontal or arc-length horizontal, as noted in Table B-2 in Appendix D of this response.

Question 7

Regarding the loss of coolant accident reanalyzed in support of this proposed amendment, please confirm that the generated χ/Q values model the limiting doses and all potential release scenarios were considered, including those due to loss of offsite power or other single failures.

Response

The LOCA analysis results were computed using the limiting or bounding credible release points (also see response to Question 2 above). The dispersion factors used for each release point reflect the maximum of the computed factors for each time step for all same-unit and cross-unit source to receptor combinations. A loss of offsite power or other single failure was determined to not have an impact on the sources and receptors modeled in a LOCA.

A loss of off-site power or a single failure would not affect the possibility of transporting activity to the control room receptors via the control room ventilation system (VC) intakes. The discussion in LAR Section 4.6.9 (Reference 2) concluded that single failures would not affect the VC inlet modeling. The flow split model testing included several control room ventilation system alignments including those with a single VC fan and those with both fans (see response to Question 4 above). These alignments bound power related single failures associated with these components and system.

References

1. Letter from B. H. Hamilton to U. S. Nuclear Regulatory Commission, *License Amendment Request for Full Scope Implementation of the Alternative Source Term. Revisions to Control Room Atmospheric Dispersion Factors*, May 28, 2008.

2. Letter from B. H. Hamilton (Duke) to U. S. Nuclear Regulatory Commission, *License Amendment Request for Full Scope Implementation of the Alternative Source Term*, March 20, 2008.

3. Letter from B. H. Hamilton to U. S. Nuclear Regulatory Commission, *License Amendment Request for Implementation of Alternative Source Term. Response to Request for Additional Information*, October 6, 2008.

4. Letter from J. F. Stang (USNRC) to G. R. Peterson (Duke) *McGuire Nuclear Station, Units 1 and 2, Issuance of Amendments Regarding Implementation of Alternative Source Term Methodology (TAC Nos. MC9746 and MC9747)*, December 22, 2006 and enclosed Safety Evaluation Report.

5. K. G. Murphy and Dr. K. M. Campe, *Nuclear Power Plant Control Room Ventilation System Design for Meeting General Criterion 19, Proceedings of the 13th AEC Air Cleaning Conference*, August 12-15, 1974, San Francisco, CA, CONF 740807, US AEC, Washington D.C.

6. USNRC Regulatory Guide 1.194, *Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants*, June 2003.

7. NUREG/CR-5055, *Atmospheric Diffusion for Control Room Habitability Assessments*, May 1988.

8. NUREG/CR-6331, *Atmospheric Relative Concentrations in Building Wakes (ARCON96)*, Revision 1, May 1997.

APPENDIX A

Application of Murphy-Campe Methodology for Distances Less Than 10m

Murphy-Campe Methodology

Murphy-Campe (Reference 5) reported that the NRC Staff developed a conservative interpretation of field data for the case in which both the release point and the receptor are located within or near the turbulence created by many buildings.

> The procedure consists of first determining the... [95th]... percentile X/Q (defined as the X/Q value exceeded [only] 5% of the time at the specific site in question). This value is used as the X/Q for the first post-accident time interval. Then the value of X/Q is reduced on the basis of averaging considerations for each subsequent time interval.

In these calculations, the methodology discussed by Murphy-Campe for a "Point or Diffuse Source – Two Alternate Receptors" is used to calculate the 1-hour (X/Q). This straight-line, Gaussian equation is shown below (equation A1), where the standard deviation parameters are evaluated for the inlet closest to the release point and K is set to zero (justification for setting K=0 was discussed in response to Question 3 in the body of these responses) in equation 6 from Murphy-Campe (Reference 5).

$$(X/Q) = 1 / [\, U(\pi \sigma_Y \sigma_Z + (a/2)) \,] \qquad \textit{Equation A1}$$

where:

a	projected area of containment building; (m^2)
π	pi = 3.1416
σ_Y	sigma-Y; the horizontal diffusion coefficient (m), which is defined as the standard deviation of the gas concentration in the lateral crosswind direction, at a distance of "x" meters downwind
σ_Z	sigma-Z; the vertical diffusion coefficient (m), which is defined as the standard deviation of the gas concentration in the vertical crosswind direction, at a distance of "x" meters downwind
U	lowest wind speed, below which winds occur only 5% of the time, determined from data measured at an elevation of 10 m; (m/s)

In order to hand-calculate the horizontal diffusion coefficients (i.e. sigma-Y, sigma-Z), the standard method used for the NRC models "XOQDOQ" and "PAVAN" was followed, as detailed by the subroutine "SSIGMA" listed in Appendix F of NUREG/CR-5055 (Reference 7). This is also the same method that is used by ARCON96 (i.e. NSIGMA1 subroutine listed in Appendix A.7 of NUREG/CR-6331 (Reference 8). See Equations A2 and A3, below, and the formula coefficients in Table A-1. The sigma calculations are shown later in this appendix.

$$\sigma_Y = (A_Y)\ (x^{0.9031}) \qquad \textit{Equation A2}$$

$$\sigma_Z = (A_{Zi})\ (x^{B_{Zi}}) + C_{Zi} \qquad \textit{Equation A3}$$

where:

A_Y a coefficient based on the 95th percentile stability class; slope of a stability curve.

A_{Zi}, B_{Zi}, C_{Zi} coefficients and functions of the slope of stability curve and distance, such that

I = 1 for ($x \leq 100$m)
I = 2 for ($100\text{m} < x \leq 1000$m)
I = 3 for ($x > 1000$m)

and x is the horizontal downwind distance between the source and the receptor (m).

Table A-1: Formula Coefficients for Sigma Calculations

	Stability Class	A_1	B_2	C_3	D_4	E_5	F_6	G_7
	A_Y	0.3658	0.2751	0.2089	0.1471	0.1046	0.0722	0.0481
A_{Zi}	i = 1	0.192	0.156	0.116	0.079	0.063	0.053	0.032
	i = 2	0.00066	0.0382	0.113	0.222	0.211	0.086	0.052
	i = 3	0.00024	0.055	0.113	1.26	6.73	18.05	10.83
B_{Zi}	i = 1	0.936	0.922	0.905	0.881	0.871	0.814	0.814
	i = 2	1.941	1.149	0.911	0.725	0.678	0.74	0.74
	i = 3	2.094	1.098	0.911	0.516	0.305	0.18	0.18
C_{Zi}	i = 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	i = 2	9.27	3.3	0.0	-1.7	-1.3	-0.35	-0.21
	i = 3	-9.6	2.0	0.0	-13.0	-34.0	-48.6	-29.2

References 7 and 8

The 1-hour X/Q calculated in Equation A1 is used for the first time interval of interest, usually 0-8 hours. For longer time averaging intervals, the wind speeds of differing percentiles are used in the 1-hour X/Q calculations.

Due to the proximity of the RX and MSSVo sources to the same unit intake, no adjustments for changes in wind direction over time were made. Also, the normal reduction based on standard occupancy factors for the control room operators was not applied in the dispersion calculations; it is applied in the dose (effluent) model. Table A-2 shows the wind speed percentiles typically used with standard Murphy-Campe time intervals.

Table A-2: Factors for Standard Time Intervals

Time Period	Wind Speed Percentile
0 – 8 hours	5th percentile wind speed
8 – 24 hours	10th percentile wind speed
1 – 4 days	20th percentile wind speed
4 – 30 days	40th percentile wind speed

Reference 5

Based on the standard application of Murphy-Campe methodology and Table A-2 above, the values listed in Table A-3 were derived for the McGuire factors affecting X/Q calculations for non-standard time intervals. The two time intervals less than the 0-8 hour standard initial period were determined using more conservative wind speeds than the 0-8 hour fifth percentile. The wind direction reduction factors and occupancy reduction factors are not applied or credited in these calculations because the sources (i.e. RX and MSSVo) are less than 10m horizontal distance from the intake on the same units.

Table A-3: Cumulative Frequency Percentiles and Wind Speeds for McGuire Including Non-Standard Time Intervals

Time Period	Wind Speed Percentile	Wind Speed (2001-2005)
0 – 2 hours	1.25th percentile wind speed	0.675 m/s
0 – 4 hours	2.50th percentile wind speed	0.855 m/s
0 – 8 hours	5th percentile wind speed	1.035 m/s
8 – 24 hours	10th percentile wind speed	1.305 m/s
1 – 4 days	20th percentile wind speed	1.755 m/s
4 – 30 days	40th percentile wind speed	2.430 m/s

Calculation of Dispersion Factors for Non-Standard Averaging Periods

Wind speed percentiles for the 2-8 hour and 4-8 hour periods are not listed in Table A-3 because the related X/Qs were determined by interpolation. Equation 21 from Reference 8 is used as the basis for the interpolation scheme used to determine the dispersion factor for a non-standard time period, given the dispersion factors associated with standard time periods. Equation A4 demonstrates the relationship between the bounding time periods (0-a and 0-b) to obtain the desired averaging period (a to b hours).

$$(X/Q)_{a\ to\ b} = [\ b(X/Q)_b - a(X/Q)_a\ ]\ /\ (b\text{-}a)$$ *Equation A4*

where:

a, b	hours bounding the desired averaging period
$(X/Q)_a$, $(X/Q)_b$	95th percentile (X/Q)s for the time periods "0-a" & "0-b"
$(X/Q)_{a\ to\ b}$	interpolated, average (X/Q) for the period (a-b hours)

This methodology was used to compute the dispersion factors for non-standard averaging periods. For the Murphy-Campe applications, the 2-8 hour and 4-8 hour factors are computed using this interpolation scheme. Where ARCON96 is employed, only the 4-8 hour factors are computed by interpolation; the 2-8 hour factors are supplied by the code.

Application of Murphy-Campe to Source to Receptor Distances Less than 10m

For sources within 10m of the air intakes, the ARCON96 model was not used. As an alternative, hand-calculations were performed, using the Murphy-Campe methodology discussed previously. Cumulative frequency distributions for standard time periods were used to determine the appropriate wind speed corresponding to the desired percentile for the entire period of years modeled (2001-2005), as shown in the Table A-3.

Atmospheric dispersion factors for the 2-8 hour and the 4-8 hour periods were determined by interpolation using Equation A4, so no explicit wind speed is determined to support the computation of those factors using the Murphy-Campe methodology.

Equations A2 and A3 were used to calculate sigmas based on a fifth percentile or higher stability class (e.g. class G, very stable) and the distance between the source and the receptor (i.e. air intake). G stability class was used because F stability has a cumulative frequency of only 93.05% in the 2001-2005 MET data.

The Murphy-Campe equation for dual air intakes was applied, using the diffusion coefficients for each source (i.e. sigmas), the cross-sectional area of the reactor building, and the appropriate wind speed associated with each time interval.

The X/Q value would also normally be adjusted for frequency of wind direction blowing the plume toward the intake. However, due to the proximity of the RX and MSSVo sources to the intakes on the same unit, the wind direction credit was not taken in this calculation. Occupancy factors would normally be applied to the 1-4 day and 4-30 day X/Q values, per Murphy-Campe (Reference 5), however, for these computations, the occupancy reduction factor is not applied to the (X/Q). Instead, the control room occupancy is applied in the dose calculation.

Murphy-Campe Method for Reactor Building (RX) Source

The following data is inserted into Equation A1 to calculate the dispersion factors for the reactor building (Table A-4). The 2-8 hour and 4-8 hour factors are computed by interpolation (Equation A4).

Receptor/Source: M1RX1 and M2RX2
Distance from containment wall to air intake, $x = 2.1$ m
5th percentile stability class = G

$$\sigma_Y = (0.0481)\ (2.1m^{\,0.9031}) \;=\; \mathbf{0.0940\ m}$$

$$\sigma_Z = (\,0.032)\ (\,2.1m^{\,0.814}) \;+\; 0 \;=\; \mathbf{0.05854\ m}$$

For source RX, "a" is the cross-sectional area of the containment building (1588 m^2).

Table A-4: McGuire X/Q Calculations for Reactor Building (RX)

Time Period	Wind Speed (m/s)	Dispersion Factor (sec/m^3)
0 – 2 hours	0.675 m/s	1.87E-03
0 – 4 hours	0.855 m/s	1.47E-03
0 – 8 hours	1.035 m/s	1.22E-03
2 – 8 hours		1.00E-03
4 – 8 hours		9.61E-04
8 – 24 hours	1.305 m/s	9.65E-04
1 – 4 days	1.755 m/s	7.18E-04
4 – 30 days	2.430 m/s	5.18E-04
Time Period	**Wind Speed (m/s)**	**Dispersion Factor (sec/m^3)**
0 – 2 hours	0.675 m/s	1.87E-03
0 – 4 hours	0.855 m/s	1.47E-03
0 – 8 hours	1.035 m/s	1.22E-03
2 – 8 hours		1.00E-03
4 – 8 hours		9.60E-04
8 – 24 hours	1.305 m/s	9.65E-04
1 – 4 days	1.755 m/s	7.17E-04
4 – 30 days	2.430 m/s	5.18E-04

Murphy-Campe Method for Main Steam Safety Valves on Outboard Doghouse (MSSVout) Source

The following data is inserted into Equation A1 to calculate the dispersion factors for the main steam safety valves located on the outboard doghouse Table A-5. The 2-8 hour and 4-8 hour factors are computed by interpolation (Equation A4).

Source/Receptor: M1MSSVo1 and M2MSSVo2
Distance from containment wall to air intake, x = 9 m
5th percentile stability class = G

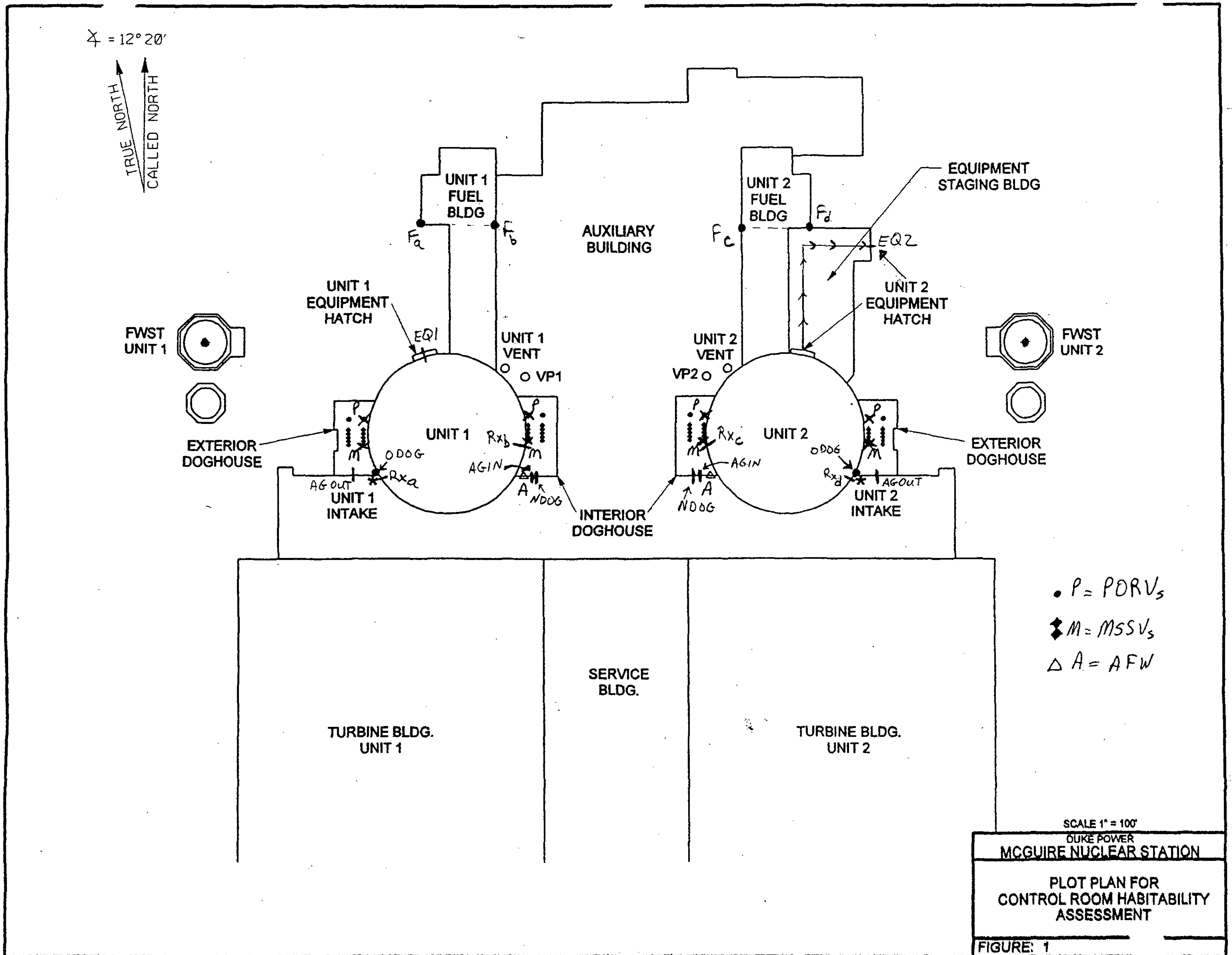
$$\sigma_Y = (0.0481)\ (9\ m^{\ 0.9031}) = \mathbf{0.35\ m}$$

$$\sigma_Z = (\ 0.032)\ (9\ m^{\ 0.814}) + 0 = \mathbf{0.19\ m}$$

For source MSSVo, "a" is the cross-sectional area of the containment building (1588 m^2).

Table A-5: McGuire X/Q Calculations for MSSVo

Time Period	Wind Speed (m/s)	Dispersion Factor (sec/m^3)
0 – 2 hours	0.675 m/s	1.87E-03
0 – 4 hours	0.855 m/s	1.47E-03
0 – 8 hours	1.035 m/s	1.22E-03
2 – 8 hours		1.00E-03
4 – 8 hours		9.60E-04
8 – 24 hours	1.305 m/s	9.65E-04
1 – 4 days	1.755 m/s	7.17E-04
4 – 30 days	2.430 m/s	5.18E-04


∡ = 12° 20′
TRUE NORTH
CALLED NORTH
UNIT 1 FUEL BLDG
UNIT 2 FUEL BLDG
Fa
Fb
Fc
Fd
AUXILIARY BUILDING
EQUIPMENT STAGING BLDG
EQ2
UNIT 1 EQUIPMENT HATCH
EQ1
UNIT 2 EQUIPMENT HATCH
FWST UNIT 1
FWST UNIT 2
UNIT 1 VENT
VP1
UNIT 2 VENT
VP2
UNIT 1
UNIT 2
P
M
Rxa
Rxb
Rxc
Rxd
ODOG
AGIN
NDOG
A
EXTERIOR DOGHOUSE
AG OUT
UNIT 1 INTAKE
UNIT 2 INTAKE
INTERIOR DOGHOUSE
TURBINE BLDG. UNIT 1
SERVICE BLDG.
TURBINE BLDG. UNIT 2
• P = PORVs
M = MSSVs
△ A = AFW
SCALE 1" = 100'
DUKE POWER
MCGUIRE NUCLEAR STATION
PLOT PLAN FOR CONTROL ROOM HABITABILITY ASSESSMENT
FIGURE: 1

Appendix B

APPENDIX C

Source-Specific Sigma-Y and Sigma-Z Diffusion Coefficients

For area sources, ARCON96 uses initial diffusion coefficients that are source specific "... to determine the distance from the center of the real source to ... [a]... virtual point source located upwind of the real source." (Reference 8) The initial diffusion coefficients (i.e. sigma-Y and sigma-Z) are determined based on the dimensions of the area source, as described below. Selection of the diffusion coefficients for use with the Murphy-Campe method of calculating X/Qs was discussed previously in Appendix A of this RAI response. Reference 6 recommends that the initial values of sigma-Y and sigma-Z for horizontal and vertical area sources be determined by the width and height of the area source (respectively) divided by 6.

The width and height are the maximum horizontal and vertical dimensions of the building's cross-section taken perpendicular to a line from the source to the receptor. Height is defined as the difference in elevation between the top of the source and the source's base, or lower edge.

$$\sigma_Y\,(m) = (\,Width_A / 6\,) \qquad \text{Equation C1}$$

$$\sigma_Z\,(m) = (\,Height_A / 6\,) \qquad \text{Equation C2}$$

For point sources, the initial diffusion coefficients are both set to zero.

Table C-1 shows the initial diffusion coefficients used in ARCON96 modeling, and the source dimensions used to calculate them.

Table C-1: Initial Diffusion Coefficients for ARCON96

	Source	Type	Sigma-Y	Sigma-Z
1	EQ	**same unit:** Vertical Area Source or Point Source **opposite unit:** Point Source	20ft = 6.1m then (6.1m/6) = **1m;** point source= 0 m.	(787.25-767ft) = 20.25ft = 6.2 m then (6.2/6) = **1m**; point source = 0 m.
2	FUEL	Horizontal Area Source	(19.1m/6) = **3.2m**	(825-760 ft) = 65 ft =19.8 m; then (19.8/6) = **3.3 m**
3	NDOG	Horizontal Area Source	(9.5m/6) = **1.6 m**	(821-760 ft) = 61 ft = 18.6m; then (18.6/6) = **3.1 m**
4	VNDOG	Vertical Area Source	(9.5m/6) = **1.6 m**	(821-800.6 ft) = 20.4 ft = 6.2 m; then (6.2/6) = **1 m**
5	ODOG	Horizontal Area Source	(9.5m/6) = **1.6 m**	(821- 760 ft) = 61 ft = 18.6 m; then (18.6 / 6) = **3.1 m**
6	VODOG	**same unit:** <u>Vertical Area Source</u> **opposite unit:** <u>Point Source</u>	(9.5m/6) = **1.6 m;** point source = 0m	(821-800.6 ft) = 20.4 ft = 6.2 m; then (6.2/6) = **1 m** point source = 0m
7	RX (opposite unit intake)	Vertical Area Source	130 ft = 39.6 m then (39.6 m/6) = **6.6 m;**	(901.25 - 767) = 134.25 ft = 40.9 m then (40.9/6) **= 6.8 m**
8	FWST	Capped Point Source	0 m	0 m
9	UV	Point Source	0 m	0 m
10	VP	Horizontal Point Source	0 m	0 m
11	AGin	Horizontal Point Source	0 m	0 m
12	AGout	Horizontal Point Source	0 m	0 m
13	PORVin	Point Source	0 m	0 m
14	PORVout	Point Source	0 m	0 m
15	MSSVin	Point Source	0 m	0 m
16	MSSVout (opposite unit intake)	Point Source	0 m	0 m
17	AFW	Horizontal Point Source	0 m	0 m

APPENDIX D

Updated and Replacement License Amendment Request Sections and Tables

The following pages provide updated information for the McGuire Alternative Source Term License Amendment Request package. The tables and text in this appendix supersede previously supplied versions in the original LAR (Reference 2), the supplement (Reference 1), and the responses to the Request for Additional Information (Reference 3). These pages and the MET data files on the compact disc (CD) represent the current status of the analyses supporting the McGuire Alternative Source Term License Amendment Request. Each page contains an individual piece of information (table or text).

In Table B-2, Table 18, Section 4.10, and Table 5-1 the changed values are indicated in **bold**.

All of the values in Table B-3, and Tables 15, 16, and 17 are impacted by the changes described in the response to the RAIs, so bolding of the entire table is not utilized to indicate the changes. However, the dispersion factors for $FWST_{0-2}$ (Refueling Water Storage Tank, Tables 15-17 and B-3) and $PORVout_{0-2}$ (Table B-3 only) did not change. The values in the shaded cells of Table B-3 represent those dispersion factors used in the LOCA effluent dose calculation models.

Table B-2 McGuire Source Parameters for ARCON96 Modeling (sheet 1 of 3)

Source Type:	**EQ[(a)]**	**FUEL**	**NDOG**	**Vndog**	**ODOG**	**VOdog**	**RX[c]**	**FWST**	**UV**	**VP**
Vertical Point Source									X	
Horizontal or Capped Point	1-CR1; 2-CR2 1-CR2; 2-CR1					1-CR2 2-CR1		X		X
Horizontal Area Source		X	X		X					
Vertical Area Source	1-CR1 2-CR2			X		1-CR1 2-CR2	X			
Release Height	8.3 m; 0m PTM 0 m VAS	19.8 m	18.6 m	0 m	18.6 m	18.6 m PT 0 m VAS	0 m	14.6 m	40.2 m	9.5 m
Flow Rate (m^3/s)	0	0	0	0	0	0	0	0	8.60 m^3/s	0
Sigma-Y	Pt. Src. 0 m Area Src. 1 m	3.2 m	**1.6 m**	**1.6 m**	1.6 m	0 m 1.6 m	**6.6 m**	0 m	0 m	0 m
Sigma-Z	Pt. Src. 0 m Area Src. 1 m	**3.3 m**	3.1 m	1 m	3.1 m	0 m 1 m	6.8 m	0 m	0 m	0 m
Bldg Cross-sectional Area *(RX or ODOG)*	1588 m^2	1588 m^2	1588 m^2	1588 m^2	opposite unit: 1588 m^2 same unit: 188.1 m^2	opposite unit: 1588 m^2 same unit: 188.1 m^2	1588 m^2	opposite unit: 1588 m^2 same unit: 188.1 m^2	1588 m^2	1588 m^2
Source/Stack Radius (m) [(b)]	0 m	0 m	0 m	0 m	0 m	0 m	0 m	0 m	0 m	0 m
Vertical Velocity[(b)]	0 m/s	0 m/s	0 m/s	0 m/s	0 m/s	0 m/s	0 m/s	0 m/s	0 m/s	0 m/s
1-CR1 Distance_WD	36 m_{arc} 32° arc	65 m 24°	54 m_{arc} 102° arc	54 m_{arc} 102° arc	11 m 349°	11 m 349°	2.1 m 71°	54 m 321°	43 m 62°	59 m_{arc} 108° arc
1-CR2 Distance_WD	116 m 298°	112 m 318°	82 m 290°	82 m 290°	128 m 287°	128 m 287°	85 m 289°	169 m 294°	94 m 299°	88 m 298°
2-CR1 Distance_WD	137 m 76°	112 m 68°	82 m 94°	82 m 94°	128 m 102°	128 m 102°	85 m 95°	169 m 90°	94 m 83°	88 m 83°
2-CR2 Distance_WD	61 m_{arc} 10° arc	65 m 1°	54 m_{arc} 281° arc	54 m arc 281° arc	11 m 32°	11 m 32°	2.1 m 313°	54 m 62°	43 m 323°	59 m_{arc} 265° arc

Table B-2 McGuire Source Parameters for ARCON96 Modeling (sheet 2 of 3)

Source Type:	AGin	AGout	PORVin	PORVout	MSSVin	MSSVout[c]	AFW[d]
Vertical Point Source			X	X	X	X	
Horizontal or Capped Point	X	X					X
Horizontal Area Source							
Vertical Area Source							
Release Height	8.5 m	8.53 m	18.9 m	18.9 m	18.8 m	18.8 m	15.5 m
Flow Rate (m^3/s)	0	0	0 m^3/s	0 m^3/s	0 m^3/s	0 m^3/s	0 m^3/s
Sigma-Y	0 m	0 m	0 m	0 m	0 m	0 m	0 m
Sigma-Z	0 m	0 m	0 m	0 m	0 m	0 m	0 m
Bldg Cross-sectional Area *(RX or ODOG)*	1588 m^2	opposite unit (Rx): 1588 m^2 same unit (Odog): 188.1 m^2	1588 m^2	Opposite unit: 1588 m^2 Same unit: 188.1 m^2	1588 m^2	Opposite unit: 1588 m^2 Same unit: 188.1 m^2	1588 m^2
Source/Stack Radius [(b)] (m)	0 m	0 m	0 m	0 m	0 m	0 m	0 m
Vertical Velocity [(b)]	0 m/s	0 m/s	0 m/s	0 m/s	0 m/s	0 m/s	0 m/s
1-CR1 Distance_WD	42 m_{arc} 80° arc	16 m 312°	43 m 79°	15 m 4°	40 m 88°	9 m [c] 357°	44 m_{arc}, 65° arc[d] or (38m, 100°) straightline
1-CR2 Distance_WD	81 m 284°	127 m 284°	82 m 293°	126 m 289°	81 m 289°	125 m 286°	85 m 283°
2-CR1 Distance_WD	81 m 102°	127 m 102°	82 m 91°	126 m 95°	81 m 95°	125 m 97°	85 m 101°
2-CR2 Distance_WD	42 m_{arc} 300° arc	16 m 85°	43 m 304°	15 m 20°	40 m 291°	9 m [c] 21°	44 m_{arc}, 317° arc [d] or (38m, 284°) straightline

Table B-2 McGuire Source Parameters for ARCON96 Modeling (sheet 3 of 3)

Notes:

(a) Three source type runs were made for the equipment hatch: point source and receptor on the same unit; point source and receptor on opposite units; and vertical area source and receptor on the same unit. The limiting case was with a point source and receptor on the same unit, representing a single hole in the hatch. The vertical area source run represents either having the hatch doorway open, or having multiple holes in the hatch.

(b) Values of zero are assumed for the vertical velocity and the stack radius parameters, to treat the release as a ground-level release in ARCON96. Plume rise of the PORV and MSSV sources is NOT accounted for.

(c) Used Murphy-Campe hand-calculation, without wind speed/direction factors, for RX and MSSVout sources on same unit as receptor intake because the separation distance is less than 10m.

(d) Selected maximum χ/Q for each time period for the AFW sources, comparing ARCON96 runs for straight line distances and arclength distances (i.e. around the reactor building).

Table B-3 McGuire Maximum (χ/Q)s per Source (McGuire 2001-2005 Meteorology)

	0-2 Hr	0-4 Hr	0-8 Hr	2-8 Hr	4-8 Hr	8-24 Hr	1-4 day	4-30 day
EQ M1E1PTMx (arc)	4.09E-03	3.88E-03	3.73E-03	3.61E-03	3.58E-03	1.72E-03	1.28E-03	9.99E-04
FUEL m1FUEL1	7.99E-04	7.37E-04	6.76E-04	6.35E-04	6.15E-04	2.85E-04	2.27E-04	1.81E-04
NDOG (arc)	1.19E-03 m2N7DOG2	9.97E-04 m1N7DOG1	8.56E-04 m2N7DOG2	7.70E-04 m1N7DOG1	7.31E-04 m2N7DOG2	3.00E-04 m1N7DOG1	2.34E-04 m2N7DOG2	1.85E-04 m2N7DOG2
VNDOG (arc)	1.57E-03 m2VNDOG2	1.45E-03 m1VNDOG1	1.22E-03 m1VNDOG1	1.12E-03 m1VNDOG1	1.03E-03 m2VNDOG2	4.32E-04 m1VNDOG1	3.27E-04 m2VNDOG2	2.53E-04 m2VNDOG2
ODOG m2ODOG2	5.04E-03	4.45E-03	4.07E-03	3.75E-03	3.69E-03	1.75E-03	1.42E-03	1.10E-03
VODOG m2VODOG2	1.74E-02	1.57E-02	1.44E-02	1.34E-02	1.31E-02	6.31E-03	5.04E-03	3.95E-03
RX- Murphy-Campe M1RX1; M2RX2	1.87E-03	1.47E-03	1.22E-03	1.00E-03	9.61E-04	9.65E-04	7.18E-04	5.18E-04
FWST m2FWST2x	1.84E-03	1.80E-03	1.75E-03	1.71E-03	1.70E-03	8.09E-04	5.97E-04	4.62E-04
UV m1UV1x	1.69E-03	1.65E-03	1.59E-03	1.56E-03	1.53E-03	7.52E-04	5.68E-04	4.32E-04
VP m2VP2x (arc)	1.58E-03	1.50E-03	1.38E-03	1.31E-03	1.26E-03	5.51E-04	4.20E-04	3.49E-04
AGIN m1AGIN1 (arc)	2.93E-03	2.88E-03	2.80E-03	2.76E-03	2.72E-03	1.23E-03	9.14E-04	6.77E-04
AGOUT m2AGOUT2	1.77E-02	1.69E-02	1.61E-02	1.56E-02	1.53E-02	6.83E-03	5.03E-03	3.78E-03
PORVin m1PORVn1	2.62E-03	2.48E-03	2.35E-03	2.26E-03	2.22E-03	1.03E-03	7.78E-04	5.80E-04
PORVout m2PORVo2	1.07E-02	1.03E-02	9.59E-03	9.21E-03	8.88E-03	3.93E-03	3.12E-03	2.51E-03
MSSVin m1MSSVn1	2.91E-03	2.80E-03	2.59E-03	2.48E-03	2.38E-03	1.07E-03	7.96E-04	5.91E-04
MSSVout Murphy-Campe M1MSSVo1;M2MSSVo2	1.87E-03	1.47E-03	1.22E-03	1.00E-03	9.60E-04	9.65E-04	7.17E-04	5.18E-04
AFW ("a" = arc)	3.33E-03 m2AFWN2s	3.06E-03 m1AFWN1s	2.61E-03 m1AFWN1s	2.38E-03 m1AFWN1s	2.30E-03 m1AFWN1a	1.13E-03 m1AFWN1a	8.26E-04 m1AFWN1a	6.32E-04 m1AFWN1a

Receptor/source nomenclature lists the receptor first, followed by source. For example, "M1UV1" represents a release from the Unit 1 unit vent ("UV1") to the McGuire unit one control room area ventilation system inlet location ("M1").

Table 15
Maximum Control Room Atmospheric Dispersion Factors (sec/m^3)

Time	Unit Vent M1UV1x	Purge System Intake M2VP2x (arc)	Equipment Hatch M1E1PTMx (arc)	Refueling Water Storage Tank M2FWST2x
0 – 2 hours	1.69E-03	1.58E-03	4.09E-03	1.84E-03
0 – 4 hours	1.65E-03	1.50E-03	3.88E-03	1.80E-03
0 – 8 hours	1.59E-03	1.38E-03	3.73E-03	1.75E-03
2 – 8 hours	1.56E-03	1.31E-03	3.61E-03	1.71E-03
4 – 8 hours	1.53E-03	1.26E-03	3.58E-03	1.70E-03
8 – 24 hours	7.52E-04	5.51E-04	1.72E-03	8.09E-04
1 – 4 days	5.68E-04	4.20E-04	1.28E-03	5.97E-04
4 – 30 days	4.32E-04	3.49E-04	9.99E-04	4.62E-04

Not adjusted for dual intakes or VC System flow split.
See footnote in Table B-3 of Appendix B for explanation of source receptor nomenclature.

Table 16
McGuire LOCA Control Room Atmospheric Dispersion Factors (Unadjusted for Control Room Area Ventilation System Intake Flow Split, sec/m^3)

Time	Unit Vent	Equipment Hatch	Refueling Water Storage Tank
0 – 2 hours	1.69E-03	4.09E-03	1.84E-03
2 – 8 hours	1.56E-03	3.61E-03	1.71E-03
8 – 24 hours	7.52E-04	1.72E-03	8.09E-04
1 – 4 days	5.68E-04	1.28E-03	5.97E-04
4 – 30 days	4.32E-04	9.99E-04	4.62E-04

Table 17
Control Room Atmospheric Dispersion Model for VC Alignments
(sec/m^3, 65/35 flow split)

Time	Unit Vent[1]	Equipment Hatch[2]	Refueling Water Storage Tank
0 – 2 hours[3]	1.10E-03	2.66E-03	1.20E-03
2 – 8 hours	1.01E-03	2.35E-03	1.11E-03
8 – 24 hours	4.89E-04	1.12E-03	5.26E-04
1 – 4 days	3.69E-04	8.32E-04	3.88E-04
4 – 30 days	2.81E-04	6.49E-04	3.00E-04

[1] Upper and lower containment bypass leakage flow path. Release point for other discharges.
[2] Upper containment bypass leakage flow path.
[3] Values to be used during 2 hour period of maximum activity release

Table 18
Off-site and Control Room Doses for the McGuire Design Basis LOCA
(Rem TEDE)

	Minimum Safeguards		
	EAB	**LPZ**	**Control Room**
Containment Effluent	8.15	1.67	**2.19**
ECCS Effluent	1.31	0.23	**0.80**
Total Effluent Dose	9.46	1.90	**2.99**
External Operator Shine Dose			1.26
Total Dose	9.46	1.90	**4.25**
Acceptance Criteria	25	25	5

4.10 CONCLUSION

Radiological consequences to a design basis Loss of Coolant Accident at McGuire Nuclear Station have been computed utilizing the guidance of RG 1.183 in a manner very similar to that submitted and reviewed for Catawba Nuclear Station. The radiological consequences are:

- The Exclusion Area Boundary dose was computed to be 9.46 Rem TEDE.
- The Low Population Zone dose was computed to be 1.90 Rem TEDE.
- The control room dose was computed to be **4.25** Rem TEDE.

The computed doses for this accident at McGuire are within the acceptance criteria of 10 CFR 50.67(b)(2).

TABLE 5-1
COMPARISON OF RESULTING AST DOSES TO ACCEPTANCE CRITERIA
(Rem, TEDE)

RECEPTOR	MCGUIRE DOSE	ACCEPTANCE CRITERIA
Control Room	**4.25**	5
EAB	9.46	25
LPZ	1.90	25

ARCON96 MET Data Files

- The attached compact disc (CD) contains the updated McGuire ARCON96 meteorological data files for each year from 2001 through 2005. Each file corresponds to the year indicated in the file name.

- These files (*.met) are text files. They can be opened into any standard text, spreadsheet, or word processing software.

- There is one meteorological file for each of the five years of data with filename structure of "MyyyyR6.met" (where yyyy indicates the calendar year associated with the data) to distinguish them from previously supplied versions.

- This CD supersedes all previously transmitted ARCON96 MET file data discs associated with the McGuire AST license amendment.